Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1936. Volume III (XII), № 2 (97)

MATHÉMATIQUES

SUR LES FONCTIONS DE CLASSE 1

Par W. SIERPINSKI

(Présenté par N. Lusin, de l'Académie, l. 9. VI. 1936)

Le but du cette Note est de prouver qu' une fonction de classe 1 de Baire définie sur un ensemble linéaire non dénombrable E peut être discontinue sur tout sous-ensemble non dénombrable de E. Notre démonstration utilise l'hypothèse du continu ($2^{\aleph_0} = \aleph_1$).

N. Lusin a construit [1] une fonction $Z(y)$ définie et continue sur l'ensemble S de tous les nombres irrationnels y de l'intervalle $(0, 1)$ et il a démontré que si $2^{\aleph_0} = \aleph_1$, il existe un ensemble non dénombrable $H \subset S$ jouissant de la propriété L^* et tel que l'ensemble $E = Z(H)$ est toujours de 1ère catégorie.

Or, j'ai démontré [2] que la fonction $f(x)$ inverse de $Z(y)$, définie sur l'ensemble $K = Z(S)$, est de classe $\leqslant 1$ sur K.

Je dis que la fonction $f(x)$ est discontinue sur tout sous-ensemble non dénombrable de l'ensemble E.

En effet supposons que ce n'est pas le cas et soit E_1 un sous-ensemble non dénombrable de E sur lequel la fonction $f(x)$ est continue. La fonction $Z(y)$ étant inverse de la fonction $f(x)$ et continue sur S on conclut sans peine, d'après $E_1 \subset E = Z(H) \subset Z(S) = K$, que la fonction $f(x)$ établit une homéomorphie entre l'ensemble E_1 et l'ensemble $f(E_1) \subset \subset f(E) = H$. L'ensemble $f(E_1)$ en tant que homéomorphe d'un ensemble toujours de 1ère catégorie (comme $E_1 \subset E$), l'est donc également. Or, c'est impossible, puisque $f(E_1)$, comme sous-ensemble de l'ensemble H jouissant de la propriété L, jouit également de cette propriété et, par conséquent, en tant que non dénombrable, ne jouit pas de la propriété de Baire [3].

Une fonction de classe 1 définie sur un ensemble linéaire peut donc présenter une singularité dont peuvent jouir sur l'intervalle tout entier seulement des fonctions non mesurables **.

Manuscrit reçu
le 10. VI. 1936.

---

* On dit qu'un ensemble jouit de la propriété L, s'il ne contient aucun sous-ensemble non dénombrable non dense. Cf. Fund. Math., 26, 137.

** Moi et A. Zygmund nous avons démontré dans Fund. Math., 4, 318 que si $2^{\aleph_0} = \aleph_1$, il existe une fonction d'une variable réelle qui est discontinue sur tout ensemble non dénombrable.

LITTÉRATURE CITÉE

[1] N. Lusin, Fund. Math., 21, 119—122 et W. Sierpinski (Monografje Matematyczne, t. IV, 65 (1934). [2] Fund. Math., 22, 263—265. [3] W. Serpinski, loc. cit., 41.

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1936. Volume III (XII), № 2 (97)

MATHEMATIK

ÜBER EINEN TOPOLOGISCHEN UNIVERSALRAUM

Von A. TICHONOV (TYCHONOFF)

(Vorgelegt von S. Bernstein, Mitglied der Akademie, d. 16. V. 1936)

Es sei $\mathfrak{R}$ eine Menge von allgemein-topologischen Räumen (1). Einen allgemein-topologischen Raum U nennen wir einen Universalraum für $\mathfrak{R}$, wenn der Raum U zu $\mathfrak{R}$ gehört und ein topologisches Bild eines jeden zu $\mathfrak{R}$ gehörenden Raumes enthält.

In seiner Arbeit «Zur Theorie der topologischen Räume» hat P. Alexandroff einen Universalraum F_τ für alle T_0-Räume (2) von Gewicht $\leqslant \tau$ konstruiert. In vorliegender Arbeit will ich eine andere Lösung desselben Problems geben, die direkt an meine alten Untersuchungen über die topologische Erweiterung von Räumen anknüpft (3).

Zu jedem Hausdorff'schen Raum R definieren wir den Raum $\Phi(R)$ aller abgeschlossenen Mengen von R folgendermassen. Wir erklären als Punkte von $\Phi(R)$ die abgeschlossenen Mengen F von R und als Umgebung eines Punktes F_0 die Menge aller F, die in einer Umgebung von F_0 (in R) liegen. Offenbar ist der Raum aller abgeschlossenen Mengen eines Hausdorffschen Raumes R ein T_0-Raum von demselben Gewicht wie R.

In meiner Arbeit «Über die topologische Erweiterung von Räumen» habe ich die allgemein-topologische Produktbildung für eine beliebige (auch unabzählbare) Menge von Faktoren eingeführt und insbesondere den Raum R_τ, d. h. das Produkt einer beliebigen Kardinalzahl τ von abgeschlossenen Strecken $[0, 1]$, eingehend untersucht. Dieser Definition gemäss ist ein Punkt von R_τ die Gesamtheit der Koordinaten $\{\ldots, x_\alpha, \ldots\}$, wobei $0 \leqslant x_\alpha \leqslant 1$ ist und die Menge aller Indizes α die Mächtigkeit τ hat. Eine Umgebung eines Punktes $\{\ldots, x_\alpha^{(0)}, \ldots\}$ erhält man, wenn man endlich viele Indizes $\alpha_1, \ldots, \alpha_n$ beliebig fixiert und alle Punkte $\{\ldots, x_\alpha, \ldots\}$ betrachtet, für welche die x_{α_i} $(i = 1, \ldots, n)$ zu beliebig aber fest gewählten Umgebungen der Punkte $x_{\alpha_i}^{(0)}$ $(i = 1, \ldots, n)$ der betreffenden Einheitsstrecken gehören. R_τ ist ein bikompakter topologischer Raum vom Gewicht τ.

Jetzt soll bewiesen werden:

Satz I. *Der Raum $\Phi_\tau = \Phi(R_\tau^*)$ ist ein Universalraum für alle T_0-Räume vom Gewicht $\leqslant \tau$.*

Beweis. Es sei R ein beliebiger T_0-Raum vom Gewicht $\leqslant \tau$. Unsere Aufgabe ist: jedem Punkt p von R eine abgeschlossene Menge $X(p) \subset R_\tau$ derart zuzuordnen, dass die Menge dieser $X(p)$, als Punktmenge in $\Phi(R_\tau)$ betrachtet, dem Raume R homöomorph ist.

$\{U_\alpha\}$ sei eine Basis von Mächtigkeit τ des Raumes R. Wir ordnen jedem Punkte p des Raumes R eine abgeschlossene Menge

$$X(p) = \{\ldots, X_\alpha(p), \ldots\}$$

des Raumes R_τ zu und zwar das Produkt der Mengen $X_\alpha(p)$ mit

$$\begin{aligned} X_\alpha(p) &= 0 && \text{für } p \subset U_\alpha, \\ X_\alpha(p) &= [0, 1] && \text{für } p \subset \overline{U}_\alpha - U_\alpha, \\ X_\alpha(p) &= 1 && \text{für } p \not\subset \overline{U}_\alpha. \end{aligned}$$

Dieses Verfahren ordnet verschiedenen Punkten p_1 und p_2 von R verschiedene Mengen $X(p_1)$ und $X(p_2)$ zu. Es bleibt nur noch zu zeigen, dass die somit definierte eineindeutige Abbildung φ von R auf die Teilmenge $\varphi(R) = R^*$ von $\Phi(R_\tau)$ in beiden Richtungen stetig ist*.

Dieser Beweis wird in zwei Schritten geführt**.

1. Es sei $X_0 = X(p)$ ein Punkt von R^* und $U(X_0)$ eine der Umgebung G von $X(p_0)$ im Raume R_τ entsprechende Umgebung von X_0. Es ist leicht zu ersehen, dass es solche Zahlen $\varepsilon_1, \ldots, \varepsilon_n$ und solche Indizes $\alpha_1, \ldots, \alpha_n$ gibt, dass die durch

$$\rho(x_{\alpha_i}, X_{\alpha_i}(p_0)) < \varepsilon_i \qquad (i = 1, \ldots, n)$$

definierte offene Punktmenge $G^{\varepsilon_1, \ldots, \varepsilon_n}_{\alpha_1, \ldots, \alpha_n}(X(p_0))$ im Raume R_τ in G enthalten ist:

$$X(p_0) \subset G^{\varepsilon_1, \ldots, \varepsilon_n}_{\alpha_1, \ldots, \alpha_n} \subset G.$$

Wir setzen nun (für dieselben α_i):

$$\begin{aligned} W_{\alpha_i} &= U_{\alpha_i} && \text{falls } X_{\alpha_i}(p) = 0, \\ W_{\alpha_i} &= R && \text{falls } X_{\alpha_i}(p) = [0, 1], \\ W_{\alpha_i} &= R - \overline{U}_{\alpha_i} && \text{falls } X_{\alpha_i}(p) = 1, \end{aligned}$$

und

$$U = \prod_{i=1}^{n} W_{\alpha_i}.$$

---

* Die hier gegebene Konstruktionsweise der Mengen $X(p)$ stimmt mit derjenigen des § 3 meiner oben zitierten Arbeit (3) überein. Dort ist bewiesen, dass die den Punkten eines Hausdorffschen Raumes zugeordneten Mengen $X(p)$ punktfremd sind und dass der betreffende Mengenraum R^* dem Raume R homöomorph ist. Von Universalraume konnte damals nicht die Rede sein, denn die T_0-Räume wurden erst 1935 (in oben zitierter Arbeit von Alexandroff und Hopf) eingeführt.

** Diese Beweise sind wörtlich identisch mit den Beweisen S. 559 der unter (3) zitierten Arbeit.

U ist offen und enthält p_0. Ferner entspricht jedem Punkte $p \subset U$ eine Menge $X(p) \subset G_{\alpha_1, \ldots, \alpha_n}^{\varepsilon_1, \ldots, \varepsilon_n} \subset G$. Damit ist die Stetigkeit der Abbildung φ von R auf R^* nachgewiesen.

2. Es seien jetzt der Punkt p_0 des Raumes R und eine seiner Umgebungen $U = U_{\alpha_0}$ gegeben. Wir betrachten die offene Menge aller Punkte $x = \{\ldots, x_\alpha, \ldots\}$ von R, für welche $|x_{\alpha_0}| < \frac{1}{2}$ gilt. Diese Menge ist eine Umgebung von $X(p_0)$. Gehört nun eine Menge $X(p)$ zu dieser Umgebung, so bedeutet das, dass $X_{\alpha_0}(p) = 0$, d. h. $p \subset U_{\alpha_0} = U$. Also haben wir eine solche Umgebung des Punktes $X(p_0)$ gefunden, dass jedem ihrer Punkte $X(p)$ ein Punkt p der gegebenen Umgebung U entspricht. Hiermit ist der Beweis der zwischen R und R^* bestehenden Homöomorphie und somit auch der Beweis des Satzes I erbracht*.

In der bereits zitierten Arbeit** untersucht Prof. P. Alexandroff das «dyadische Diskontinuum» D_τ welches als Produkt von Punktpaaren definiert wird. Offenbar bildet D_τ eine abgeschlossene Menge in R_τ.

Satz II. *Der Raum $\Phi(D_\tau)$ ist ein Universalraum für alle T_0-Räume vom Gewicht $\leqslant \tau$.*

Es genügt in der Tat jedem Punkt p von R die Menge

$$Y(p) = \{\ldots, Y_\alpha(p), \ldots\}$$

nach der Vorschrift:

$$Y_\alpha(p) = 0 \qquad \text{falls } p \subset U_\alpha,$$

$$Y_\alpha(p) = \{0, 1\} \qquad \text{falls } p \subset \bar{U}_\alpha - U_\alpha,$$

$$Y_\alpha(p) = 1 \qquad \text{falls } p \not\subset U_\alpha,$$

zuzuordnen und sodann den obigen Beweis des Satzes I wörtlich zu wiederholen***.

Mathematisches Institut
der Universität Moskau.

Eingegangen
d. 16. V. 1936.

ZITIERTE LITERATUR

[1] Vgl. wegen Terminologie und Bezeichnungen Alexandroff-Hopf, Topologie I, Kap. I und II (1935). [2] Alexandroff, C. R. Acad. Sci URSS, II, 2 (1936). [3] Siehe A. Tychonoff, Über die topologische Erweiterung von Räumen, Math. Ann., **102**, 544 (1929).

---

* Ist R ein bikompakter Hausdorffscher Raum, so bildet die Gesamtheit aller $\{X(p)\}$ eine abgeschlossene Menge in R_τ. Das schliesst man aus dem folgenden leicht zu beweisenden Satz: Sind den Punkten p eines bikompakten topologischen Raumes R die punktfremden bikompakten Untermengen $X(p)$ eines topologischen Raumes E zugeordnet derart, dass $\{X(p)\}$ als Relativraum R^* des Raumes $\Phi(E)$ betrachtet, dem Raume R homöomorph ist, so bildet die Gesamtheit aller $\{X(p)\}$ eine bikompakte Untermenge von E.

** Siehe die unter [2] zitierte Arbeit.

*** Mit Hilfe des soeben bewiesenen Satzes und der in den Fussnoten gemachten Bemerkungen erhält man unmittelbar einen Beweis des Satzes II der unter [3] zitierten Arbeit.

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1936. Volume III (XII), № 2 (97)

HIMMELSMECHANIK

ÜBER EINE QUANTITATIVE CHARAKTERISTIK DER QUALITATIVEN BERÜHRUNGSTHEORIE

Von N. MOISEJEV (Moisseiev)

(Vorgelegt von V. G. Fesenkov, Mitglied der Akademie, d. 26. V. 1936)

Wir betrachten eins der Schemata der Himmelsmechanik, das ein Integral vom Typus des Jacobischen Integrals zulässt, und schreiben die Differentialgleichungen der zweidimensionalen Bewegung des massenlosen Punktes in der Birkhoffschen Form:

$$\left.\begin{aligned} \dot{x} &= \sqrt{2(U+h)}\cos\varphi = X, \\ \dot{y} &= \sqrt{2(U+h)}\sin\varphi = Y, \\ \dot{\varphi} &= -2n + \frac{U'_y\cos\varphi - U'_x\sin\varphi}{\sqrt{2(U+h)}} = \Phi, \end{aligned}\right\} \tag{1}$$

nieder, wo

$$U = U(x, y) \tag{2}$$

ist und h und n die Konstanten sind.

Nehmen wir an, dass der Birkhoffsche Phasenraum (x, y, φ) in irgend einem Anfangsmoment t_0 mit gleichförmiger Dichte $\varkappa$ von Phasenpunkten ausgefüllt, ist dann wird, der Inkompressibilitätsbedingung

$$\frac{\partial X}{\partial x} + \frac{\partial Y}{\partial y} + \frac{\partial \Phi}{\partial \varphi} = 0 \tag{3}$$

zufolge, diese Dichteverteilung für alle Zeiten $t > t_0$ invariant bleiben.

Indem wir uns mit der Betrachtung des Teils

$$0 \leqslant \varphi \leqslant 2\pi \tag{4}$$

des Phasenraums begnügen, wollen wir in diesem Aufsatze eine Eigenschaft der Strömung der Birkhoffschen Phasenflüssigkeit untersuchen.

Es seien

$$f(x, y) = c_1$$

und

$$f(x, y) = c_2 = c_1 + \Delta c; \quad \Delta c > 0 \tag{6}$$

zwei benachbarte Flächen einer einparametrigen topographischen Schar (1) der Zylinderflächen

$$f(x, y) = c, \tag{7}$$

deren Leitlinien auf der xy-Ebene sämtlich geschlossen sind, und es sei $\mathfrak{R}_{c_1}^{c_2}$ der Raumteil, der durch diese Flächen (5) und (6) begrenzt ist.

Wir betrachten nun den Strom der Phasenflüssigkeit, der durch die Oberfläche (6) ins Innere des Volumens $\mathfrak{R}_{c_1}^{c_2}$ in eine Zeiteinheit eintritt und der durch folgende Formel gegeben ist:

$$\mathfrak{F}(c_2) = -\varkappa \int\int \frac{\sqrt{2(U+h)}}{\sqrt{f_x'^2 + f_y'^2}} (f_x' \cos\varphi + f_y' \sin\varphi)\, d\sigma, \tag{8}$$

wo das Integral auf denjenigen Teil der Oberfläche (6) zu erstrecken ist, in dessen jedem Punkte die Ungleichung

$$f_x' \cos\varphi + f_y' \sin\varphi < 0 \tag{9}$$

gilt.

Die Menge $E(c_2)$ der Phasenpunkte, die durch (6) ins $\mathfrak{R}_{c_1}^{c_2}$ eintreten, kann man in drei folgende Teilmengen zerlegen:

$E_1(c_2)$,—umfasst, Punkte die nach dem Durchsetzen der Oberfläche (6) wieder aus dem Volumen $\mathfrak{R}_{c_1}^{c_2}$ durch dieselbe Oberfläche (6) heraustreten;

$E_2(c_2)$, — umfasst Punkte, die nach dem Durchsetzen der Fläche (6) niemals aus dem Volumen $\mathfrak{R}_{c_1}^{c_2}$ heraustreten, und schliesslich,

$E_3(c_2)$, — umfasst Punkte, die nach dem Durchsetzen der Fläche (6) aus dem Volumen $\mathfrak{R}_{c_1}^{c_2}$ durch die Oberfläche (5) heraustreten.

Indem wir die diesen drei Untermengen entsprechenden Partialströme durch die Symbole $\mathfrak{F}_1(c_2)$, $\mathfrak{F}_2(c_2)$ und $\mathfrak{F}_3(c_2)$ bezeichnen, können wir folgende Formel schreiben:

$$\mathfrak{F}(c_2) = \mathfrak{F}_1(c_2) + \mathfrak{F}_2(c_2) + \mathfrak{F}_3(c_2). \tag{10}$$

Nun betrachten wir den Strom der Phasenteilchen, der aus dem Volumen $\mathfrak{R}_{c_1}^{c_2}$ durch die Oberfläche (5) in eine Zeiteinheit heraustritt. Dieser Strom wird durch eine der Formel (8) analoge Formel gegeben. Das Integrationsgebiet wird durch eine Bedingung, die der Bedingung (9) analog ist, bestimmt. Die Menge $E(c_1)$ der Phasenpunkte, die diesen Strom $\mathfrak{F}(c_1)$ bilden, kann man in drei folgende Untermengen zerlegen:

$E_1(c_1)$—umfasst Punkte, die vor dem Heraustreten aus dem Volumen $\mathfrak{R}_{c_1}^{c_2}$ in dasselbe durch die Oberfläche (6) eingetreten sind,

$E_2(c_1)$—umfasst Punkte, die vor dem Heraustreten aus dem Volumen $\mathfrak{R}_{c_1}^{c_2}$ weder (5) noch (6) durchgesetzt haben, und schliesslich,

$E_3(c_1)$—umfasst Punkte, die vor dem Heraustreten aus dem Volumen $\mathfrak{R}_{c_1}^{c_2}$ in dasselbe durch die Oberfläche (5) selbst eingetreten sind.

Also erhalten wir:

$$\mathfrak{F}(c_1) = \mathfrak{F}_1(c_1) + \mathfrak{F}_2(c_1) + \mathfrak{F}_3(c_1), \tag{11}$$

wo $\mathfrak{F}_1(c_1)$, $\mathfrak{F}_2(c_1)$ und $\mathfrak{F}_3(c_1)$ Partialströme sind, die beziehungsweise den drei eben erörterten Untermengen $E_1(c_1)$, $E_2(c_1)$ und $E_3(c_1)$ entsprechen.

Lassen wir weiter zu, dass die Flächen (5) und (6) so gewählt sind, dass innerhalb des Volumens $\mathfrak{R}_{c_1}^{c_2}$ keine singulären Punkte des Systems (1) vorhanden sind, so werden folgende Formeln gelten ([2], [3]):

$$\mathfrak{F}_2(c_1) = \mathfrak{F}_2(c_2) = 0, \tag{12}$$

$$\mathfrak{F}_3(c_1) = \mathfrak{F}_3(c_2). \tag{13}$$

Infolgedessen können wir die Differenz $\mathfrak{F}(c_2) - \mathfrak{F}(c_1) = \Delta\mathfrak{F}$, die ohne irgend eine Hilfe der Integrale des Systems (1) berechnet werden kann, in folgender Form darstellen:

$$\Delta\mathfrak{F} = \mathfrak{F}_1(c_2) - \mathfrak{F}_1(c_1). \tag{14}$$

Es gibt zwei Sonderfälle, in denen die rechte Seite der Gleichung (14) eine ausserordentlich einfache Form annimt und nämlich:

Wenn das Volumen $\mathfrak{R}_{c_1}^{c_2}$ im Gebiete der ausschliesslich-äusseren Berührungen zwischen Trajektorien des Systems (1) einerseits und den Flächen der Schar (7) andererseits d. h. im Gebiete $\ddot{f}^+$ gelagert ist ([1]), so wird $\mathfrak{F}_1(c_1)$ gleich Null sein, während $\mathfrak{F}_1(c_2)$ der Anzahl der Punkte gleichen wird, die in eine Zeiteinheit durch die innerhalb des Volumens $\mathfrak{R}_{c_1}^{c_2}$ gelegenen Punkte der äusseren Berührungen durchgehen. Wenn aber das Volumen $\mathfrak{R}_{c_1}^{c_2}$ im Gebiete der ausschliesslich-inneren Berührungen, d. h. im Gebiete $\ddot{f}^-$ eingeschlossen ist, so wird $\mathfrak{F}_1(c_2)$ gleich Null sein, während $\mathfrak{F}_1(c_1)$ die Anzahl der Punkte darstellen wird, die in eine Zeiteinheit durch die innerhalb des Volumens $\mathfrak{R}_{c_1}^{c_2}$ gelegenen Punkte der inneren Berührungen gehen.

Im allgemeinen Falle, wo innerhalb des Volumens $\mathfrak{R}_{c_1}^{c_2}$ sowohl innere, als auch äussere Berührungen stattfinden können, lässt der Ausdruck (14) eine so leichte Interpretation nicht zu. Indem wir eine eingehende Analyse dieses Ausdrucks (14) bei Seite lassen, wollen wir in diesem Aufsatze unsere Aufmerksamkeit einer anderen Charakteristik schenken, die aus (14) abgeleitet werden kann, und die auch im allgemeinen Falle ihre Bedeutung nicht verliert.

Unter den Phasenpunkten, die die Untermenge $E_1(c_2)$ umfasst, gibt es solche, die innerhalb des Volumens $\mathfrak{R}_{c_1}^{c_2}$ nur eine einzige Berührung haben können. Den Teil des Stromes $\mathfrak{F}_1(c_2)$, der diesen Punkten entspricht, bezeichnen wir durch das Symbol $\mathfrak{F}_1^1(c_2)$. Nun lassen wir den Parameterzuwachs Δc gegen Null streben. Dann werden alle drei Ströme $\mathfrak{F}_1(c_2)$, $\mathfrak{F}_1^1(c_2)$ und $\mathfrak{F}_1(c_2) - \mathfrak{F}_1^1(c_2)$ auch gegen Null streben. Aber es ist ersichtlich, dass im allgemeinen Falle die zwei ersten dieser Ströme von einer und derselben Ordnung sind, während der letzte, d. h. $\mathfrak{F}_1(c_2) - \mathfrak{F}_1^1(c_2)$, von höherer Ordnung sein soll. In bezug auf den Strom $\mathfrak{F}_1(c_1)$ sind ganz analoge Bemerkungen geltend.

Also dürfen wir die Grösse

$$\mathcal{E}(c)\,dc = \frac{d\mathfrak{F}(c)}{dc}\,dc = \lim_{\Delta c \to 0}\left[\frac{\Delta\mathfrak{F}(c)}{\Delta c}\right]dc, \tag{15}$$

die auch ohne jegliche Hilfe der Integralen des Problems (1) berechnet werden kann, als ein Mass der Überzahl betrachten um welche die Anzahl der Durchgänge durch die Punkte der äusseren Berüh-

rungen innerhalb der unendlich dünnen Schicht $\Re(dc)$ die auf dieselbe Schicht bezogene Anzahl der Durchgänge durch die Punkte der inneren Berührungen übersteigt.

Indem wir die Fragen über die Existenz der Grösse (15), wie auch über die Möglichkeit, das Resultat der Integration derselben Grösse nach c in irgend einigen endlichen Grenzen wieder als ein Mass der Überzahl der äusseren Berührungen zu bezeichnen, u. s. w. bei Seite lassen, möchten wir zum Schluss dieses Aufsatzes noch auf einige Anwendungen der ebenerörterten Charakteristik hinweisen.

Wie bekannt [4], spielt in der wissenschaftlichen Kosmogonie eine wichtige Rolle die Frage über die Verteilungen der Elemente der Kometen- und Meteorbahnen. Aber bis jetzt gelang es diese Frage nur in der Voraussetzung zu lösen, der einzige störende Körper sei die Sonne. Nehmen wir ins Auge, dass es manche Schemata der Himmelsmechanik gibt, die der Natur mehr nah liegen als das genannte vereinfachte Schema des einzigen anziehenden Zentrums, die auch ein Integral vom Typus des Jacobischen Integrals zulassen, so wird es ersichtlich, dass unsere quantitative Charakteristik (15) der qualitativen Berührungstheorie uns eine einfache Methode für die Lösung der Fragen, die derjenigen über die Perihelenverteilung analog sind, mindestens in den gewissen Voraussetzungen über die Verteilung der Geschwindigkeitsrichtungen, bieten kann.

Staatliches Astronomisches Institut.
Moskau.

Eingegangen
d. 26. V. 1936.

ZITIERTE LITERATUR

[1] H. Моисеев, Publ. de l'Inst. Astron. de Moscou, 7, 1 (1936). [2] E. Hopf, Math. Ann., **103**, 710—719 (1930). [3] H. Zeipel, Bull. Astr., XXII, 449—490 (1905). [4] N. Moisseiev, Publications de l'Inst. Astronom. de Moscou, **5** (1927). [5] N. Moisseiev, C. R. Acad. Sci. URSS, I, 2 (1936).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1936. Volume III (XII), № 2 (97)

BIOPHYSICS

THE PHYSICAL CHARACTERISTICS OF THE MIMICRY OF FISH

By V. S. LUKJANOVA

(Communicated by S. I. Wawilow, Member of the Academy, 6. VI. 1936)

In the well-known works of the American physiologist Mast (1) and of the English physiologists Humble and Keeble (2) consecrated to the problems of mimicry, extremely curious observations of the mimicry of animals are given.

Thus, Mast records the ability of the plaice (*Paralichtis albigutus*) to change quickly the colour of its body along with the transfer from one ground to another. This phenomenon of active homochromy is due to the existence in the animal's skin of chromatophores hued in different colours and to the ability of these to vary their area by means of contraction and extension. Mast had placed a plaice on blue, red, green and yellow grounds and it had successfully recoloured itself in all the corresponding colours. Furthermore the plaice can copy not only the hue of the ground but even its pattern—the stones of different shape and size, the pebbles in the ground, the chess-board pattern painted on the bottom of the aquarium etc.

The part of the researches made by Mast in order to ascertain the role of the fish's vision in the mimicry processes is particularly interesting. To do this, Mast had placed the plaice's head on black ground so as to let it see only this black part; the body was placed on white ground; in this case the colour of the plaice became darker. On the contrary when the head had been put on white ground and the body on black one, the body of the fish became white. When the plaice had been deprived of vision it lost its capacity to change its colour. By these experiments Mast had clearly shown that the phenomenon of mimicry is closely connected to the visual perception.

Humble's and Keeble's observations over the shrimp (*Hyppolite varians*) have shown that the latter is able to reproduce skilfully the colour and pattern of seaweeds where it lives. The only difference is that the mimicry process of the shrimp is much quicker than that of the plaice. Mast's plaice recoloured itself in 2 days and the shrimp—in about 2 hours.

But in the researches quoted the judgment of the rate of the change of colour and of the perfection of the copying of the ground by the animal examined had a totally subjective visual character. The present work has in view to give an entirely objective and accurate estimation of mimicry by means of spectral characteristics.

The first experiments at the Black Sea Hydrophysical Station had been made with a plaice and afterwards the *Solea nosata* was chosen, for this fish proved to be more fit for long-time experiments owing to its endurance and tenacity of life. The experimental fish was placed into a glass aquarium illuminated from above. Coloured material was put under the bottom of the aquarium; to avoid considerable losses of the light reflection in the layer between the bottom of the glass aquarium and the material (in the air), the material was moistened with water, as the refraction index of water is nearer to that of glass than the refraction index of air. In some of the experiments the ground was made of material coloured with enamel paint. In this case the wet material was pasted to the bottom and to 1.5—2 cm of the walls of the aquarium in order to make it better visible to the fish. In

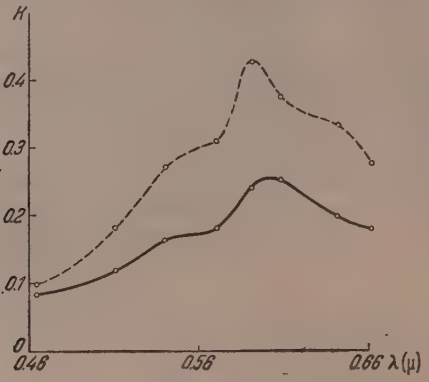


Fig. 1.

one case a window sill painted with the mixture of ochre and white lead was used as ground.

After living 3—4 days on the coloured ground the fish assumed a completely definite hue of the ground; truly this hue was considerably less pronounced, but at any rate it was perfectly stabilized and visible to the eye.

To determine the quantitative characteristics of colour I have used König-Martens's spectrophotometer. The graduation of the apparatus was performed by means of a discharge tube filled with helium. Having taken from the tables the wave lengths corresponding to the lines of helium it was easy to determine the value of the points of the micrometer which moves the tube of the apparatus along the whole spectrum.

In order to be spectrophotometered the fish was transferred from the aquarium into a bowl with a thin layer of water; the bowl was set in front of the apparatus in such a way as to place the fish in one field of the spectrophotometer and a white milky glass—in the other. The spectrum of the ground used for the mimicry of the fish was investigated in the same way. As the result we got the coefficients of reflection in all the visible sections of the spectrum, for the surface of the fish body as well as for the ground.

Having found out the spectral characteristics of the object and those of the ground, we have only to compare them to one another in order to get an objective picture of the mimicry of our fish.

For that purpose we draw the spectral curves. We mark the wave lengths along the horizontal axis and the coefficients of reflection along the verti-

cal one. The uninterrupted lines of the graph give us the spectral curves for the fish and the broken ones—those for the ground*.

Fig. 1 represents the results corresponding to the 3 day stay of the fish on the yellow ground.

Fig. 2 gives the results of the spectrographometering of the fish transferred to a blue ground and kept there for 4 days. Furthermore on this figure

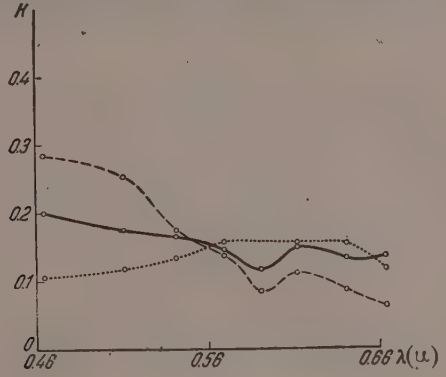


Fig. 2.

the dotted line shows the intermediate picture of the reflection spectrum of the fish when changing from yellow colour to the blue one (taken 2 days after the transfer from the yellow ground to the blue one).

Fig. 3 shows the results obtained after a 4 day keep of the fish on the red ground.

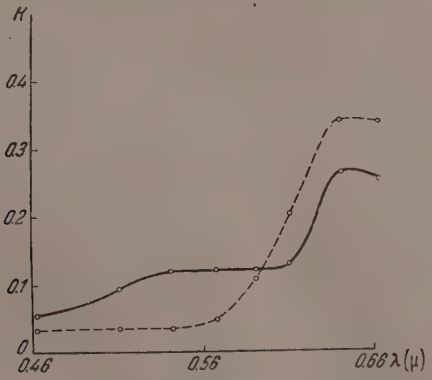


Fig. 3.

In exammining these curves we notice first of all that all the spectra of reflection from the surface of the fish body repeat more or less the spectra of the ground. Thus, the spectral curve of the fish on Fig. 2 in its first half

* The albedo of the white milky glass was equal to 0. 8. The figures serving to draw the diagrams 1—3 were not multiplied by this quantity, because the control experiment has shown that the glass was lighted stronger than the surface of the object examined (the lamp was a little nearer to the first); the ratio of the force of the light falling was approximately equal to 0.8.

does not reproduce the spectrum of the ground accurately whereas in the second part the fish copies all its minute tendencies, the maxima and minima. The spectrum of the yellow ground (Fig. 1) is particularly well copied by the fish. Here the spectral curves of the fish repeat those of the ground. It seems that the *Solea nosuta* has the greatest number of the chromatophores (or uses them more successfully) more or less resembling the colour of the fish's usual surroundings: namely the greyish-brownish-yellow ground where the fish lives.

We must dwell especially on the dotted curve of Fig. 2. As we have mentioned above, it represents the spectrum of reflection of the fish taken 2 days after the fish, having recoloured itself on the yellow ground, had been transferred to the blue one. As it ought to be expected the spectrum of the fish on this curve occupies the position between the spectra of the yellow and the blue colour of fish.

All the curves examined show that the fish can not only distinguish colours and adapt itself to them, but that its mimicry tends to be an a b s o l u t e one. The fish does not perceive some separate equivalent colour (as the mon does) but it perceives the energy distribution in the spectrum—which the man cannot observe without a spectrophotometer.

The present work has been carried out at the suggestion and under the immediate guidance of Prof. V. V. Šulejkin to whom I want to express my deep gratitude.

Black Sea Hydrophysical Station.

Received 6. VI. 1936.

REFERENCES

[1] S. O. M a s t, Bull. U. S. Bureau of Fisheries, XXXIV. [2] H u m b l e a. K e e b l e, Quart. Journ. Microscop. Sci., **43** (1930).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1936. Volume III (XII), № 2 (97)

PHYSICAL CHEMISTRY

ON THE INFLUENCE OF THE SOLVENT ON THE KINETICS OF BIMOLECULAR REACTIONS IN SOLUTIONS

By B. I. SVEŠNIKOV

(Communicated by S. I. Wawilow, Member of the Academy, 16. V. 1936)

In spite of the abundance of experimental evidence available, it has not yet been made quite clear in what manner the kinetics of reactions in solutions is affected by the fundamental properties of the solvent, and, in particular, by its viscosity.

Those experimentalists who have investigated the influence of the viscosity of the solvent on the velocity of the reaction have so far failed to obtain concordant results. In some cases an increased viscosity of the medium reduces the velocity of the reaction, in others the latter is accelerated, while in some experiments the substitution of a more viscous solvent for a less viscous one leaves the velocity of the reaction unchanged ([1]).

The contradictory results of the experiments give rise to great divergencies of views as to the part played by the viscosity of the medium in determining the number of effective collisions between the molecules of the solutes. Some authors ([1], [2]) believe that the number of such collisions is absolutely unaffected by the viscosity of the medium. Their assertion seems to be based on the well-known fact that the viscosity of the medium cannot affect the number of all the solute/solute collisions.

In making this assertion they do not discriminate between primary and secondary collisions and assume the constant of the reactions to be simply proportional to the total number of all the collisions between the molecules of both constituents of the reaction.

In examining the bimolecular reactions in solutions they therefore use, for the reaction constant k, the same expression as that usually adopted for gaseous reactions.

Others ([3]) suppose the number of effective collisions between the molecules of both reagents to be proportional to the viscosity of the medium. J. K. Syrkin, for instance, gives for the number of such collisions the following formula:

$$Z = \frac{c^2 n_1 n_2}{3ND}, \qquad (1)$$

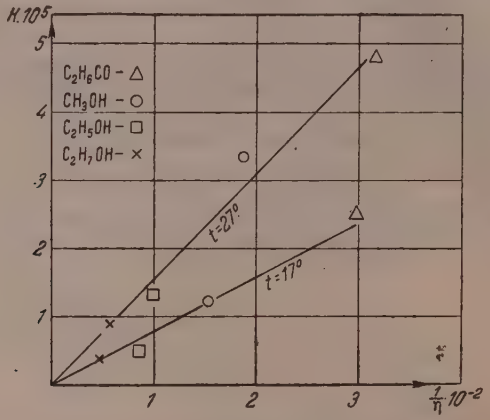
where n_1 and n_2 are the number of molecules of the first and the second reagent respectively, c—mean velocity, N—the sum total of all the molecules of the solvent and of the solute, and D—the coefficient of diffusion.

J. K. Syrkin's formula can, however, hardly be regarded as correct. According to that formula, it ought to be expected that the number of all the collisions between the molecules of the solute ought to increase (!) with the increase of viscosity, while in reality the number of such collisions is not affected by viscosity (4).

In deducing Formula (1), Syrkin extrapolates the formula:

$$\overline{X^2} = n\overline{x^2}, \qquad (2)$$

based on the admission that the displacements of the particle within various intervals of time are statistically independent values for the case when x is equal to the length of the free path*. It is known, however, that the admis-



sion of the independence of the displacements holds good only if $\lambda t \gg 1$, where $\lambda =$ (coefficient of friction /mass of the molecule).

Unless this condition is satisfied, the state of the particle may not be regarded as determinable by its position alone. A formula of greater precision (5) is applicable in this case, viz.:

$$\overline{x^2} = 2D\left[t - \frac{1 - e^{-\lambda t}}{\lambda}\right]. \qquad (3)$$

It should be noted that even formula (3) is only aplicable if τ—the time of the free run — satisfies the condition $\lambda\tau \ll 1$, as otherwise we must apply, instead of (3), a more complex formula given in Krutkow's article referred to above.

Nor does Syrkin's formula (1) agree with the experimental evidence obtained by himself (6) and I. T. Gladyschew. Those authors determined the influence of the solvent and the temperature on the kinetics of the reaction thus:

$$CH_3I + (C_2H_5)_2S \rightarrow (C_2H_5)_2CH_3SI.$$

A simple examination of the results obtained by Syrkin and Gladyschew makes it obvious that, contrary to Formula (1), k does not increase with viscosity, but decreases, so that by plotting isotherms for the constant of

* E. A. Moelwyn-Hughes (1) makes a similar mistake in determining the number of collisions between the molecules of the solute and those of the solvent. He deduces the length of the free path direct (!) from Einstein's formula.

the reaction as a function of fluidity, we should obtain a fairly good proportionality between the two (*v.* Figure).

This suggests two very probable conjectures: 1) that the number of effective solute/solute collisions varies, in the case of this reaction, inversely as the viscosity, and 2) that the energy of activation of the reacting molecules is practically the same for all the four solvents.

One fact, however, is usually left out of account, viz., that a change of temperature affects viscosity, and, consequently, the number of primary collisions. If, therefore, the energy of activation E is calculated according to Arrhenius's formula from the change of k with te mperature, k must every time be reduced to viscosity alone.

If the number of collisions is assumed to be inversely proportional to the viscosity, the values of E for the various solvents in the reaction under consideration would be, subject to the above correction, from 11 to 13.5 Cal., as against this, however, Syrkin and Gladyschew, using formula (2) obtained 21.7 Cal. for the energy of activation in propyl alcohol, and 13.3 Cal. in acetone.

A good proportionality between the constant of the velocity of the reaction and the fluidity involved in the reaction examined by Syrkin and Gladyschew is, however, rather an exception. If any parallelism is observed between k and $\frac{1}{\eta}$ for a number of reactions, it is, usually, only a qualitative one. In the general case, however, as stated above, the substitution of more viscous solvents for less viscous ones does not affect the velocity of the reaction; sometimes such a substitution accelerates the reaction, although the energy of activation remains practically unchanged.

The most usual interpretation of this phenomenon in chemical literature is that the cases when the constant of the velocity of the reaction is unaffected by the viscosity of the medium are normal, while those where the constant of the velocity of the reaction either decreases or increases with viscosity are respectively a negative or a positive catalytic effect of the solvent ([1]). Still, in spite of the complexity of the question, it appears to be possible to supply a phisical interpretation of the dependence of the constant of the velocity of the reaction upon the viscosity of the solvent.

According to modern ideas ([1]), the reacting molecules are activated not only by a violent collision, between themselves at the moment of the reaction, but by previous collisions to which they have been subjected, and enter the reaction in an already active state. It is not impossible to ascribe certain duration to that active state. The duration of the active state of a molecule in a chemical reaction is usually assumed to be of the order of 1.10^{-13}—1.10^{-15} sec. ([1]), it being taken for granted that an active molecule is easily disactivated by its first collisions with the molecules of the solvent. The experiments of Kneser ([7]) on the dispersion of supersonic waves have shown, however, that it is possible to keep the molecule in an active state for the space of 1.10^{-6} sec., in spite of the enormous number of impacts it has to undergo in that space of time.

If we now assume that under thermal excitation the molecules of the solutes may possess different values of the mean life of the excited state, from 1.10^{-15} to, say, 1.10^{-7} sec., the differences in the behaviour of the reactions with regard to the viscosity of the solvent are at once explained.

If, indeed, the molecules of the constituents of a reaction can be easily disactivated by the solvent and have a mean life of the excited state of

about 1.10^{-13}—1.10^{-15} sec., the number of impacts to be undergone by the excited molecules within so short a space of time, and, therefore, the probability of the reaction, will only be determined by the initial velocities of the reacting molecules and will not be affected by the viscosity of the solvent.

In such cases, however, when the velocity of the reaction is diminished by an increase of viscosity, we shall assume that the values of the mean life of the excited state of an activated molecule may be taken to be the same as those due to optical excitation (1.10^{-10}—1.10^{-7} sec.).

Given such a life of the activated molecule, the number of effective collisions between the molecules of the reacting substances, and, consequently, k, will decrease with an increase of viscosity.

Two distinct cases may arise in this connection: 1) the case where the reaction is caused by the very first impact of the reacting molecules, and 2) the case where probability of a reaction caused by one collision only (p) is considerably less than 1.

In the first case, when the probability of a reaction due to one collision is equal 1, the formula given by S. I. Wawilov ([8]) in his theory of the quenching of the fluorescence of dyestuff solutions may be applied. To the first approximation, this formula gives the number of primary collisions during the period of time from t to $t+dt$ as

$$Z = 4\pi Drn_1n_2dt, \qquad (4)$$

where r is the radius of the sphere of action, the other notations being the same as before.

In this case, therefore, the constant of the velocity of the reaction varies inversely as the viscosity, as this is the case for the reaction examined by Syrkin and Gladyschew.

In the second case, when the probability of a reaction caused by one collision is only a slight one, repeated impacts will be of great importance, especially in viscous media, so that the reaction constant will not be a linear function of fluidity.

Indeed, in accordance with formula (4), the probability of an excited molecule undergoing within the short period of time corresponding to the mean life of the excited molecule, an effective collision with a molecule of the second constituant of the reaction is proportional to the number of molecules of the second component that would happen to get within the sphere described by the excited molecule in the process of mutual diffusion in that period of time. This would at once give us the number of possible effective collisions, if the probability of a reaction due to an impact were equal to 1. Should, however, the probability of a reaction being caused by a single collision be less than 1, all kinds of secondary impacts would also have to be taken into account. It may, therefore, be assumed, to the first approximation, that the number of secondary collisions taking place between the excited molecule and every molecule of the second component is equal to $\frac{\nu}{\nu_1}$, where ν is proportional to the total number of all collisions, both primary and secondary, and, as stated above, is not affected by viscosity, whereas ν_1 is proportional to the number of primary collisions, which is inversely proportional to viscosity.

Elementary calculations would then show that the number of effective collisions may be derived from the formula:

$$Z = \left[1 - (1-p)^{\frac{\nu}{\nu_1}}\right] Z_1, \qquad (5)$$

where p is the probability of a reaction being produced by a single impact. In this formula $\frac{\nu}{\nu_1} \sim \eta$ and $Z \sim \frac{1}{\eta}$. If $p = 1$, formula (5) is replaced by formula (4).

The above hypothesis, which assumes the life time of an excited molecule to be between 1.10^{-15} and 1.10^{-7} sec., also implies a definite dependence of the constant of the velocity of the reaction on the concentration of the reacting substances. The molecules of the reacting substances must become excited and die off in accordance with some kind of law. Unfortunately this law is unknown to us. Probably we should be justified in adopting a scheme similar to that of the photochemical reaction. Then, as shown by calculations*, if the concentration of the reacting molecules increased a certain number of times, the number of effective collisions would increase a smaller number of times (according to the value of τ), as more shortlived molecules would also be involved in the reaction. The constant of the velocity of the reaction would, therefore, diminish as the concentration of the reacting substances increased. This is known to be generally the case with most reactions.

Experimental investigations in support of the above hypothesis are hampered by the fact that, out of the three parameters, viz.: viscosity, energy of activation and the mean life of the excited molecule, which may change from solvent to solvent, we have no method for determining the last-named parameter in the case of an ordinary bimolecular reaction.

In applying the analogy with the phenomena of the quenching of the fluorescence of dyestuff solutions by means of secondary collisions, where the values of τ are known for various solvents, it may be said that, for this particular case of bimolecular reactions, the number of collisions is undoubtedly reduced by viscosity.

In conclusion, I deem it a pleasant duty to express my profound gratitude to S. I. Wawilow, Member of the Academy of the USSR and Prof. M. A. Leontowitsch for a number of valuable suggestions.

State Optical Institute.
Leningrad.

Received
15. V. 1936.

REFERENCES

[1] Moelwyn-Hughes, The Kinetics of Reactions in Solution. Oxford (1933). [2] R. G. W. f, Norrish a. F. F. P. Smith, Trans. Chem. Soc., 129 (1928).—M. Polissar, J. Am. Chem. Soc, **54**, 3105 (1932). [3] J. K. Syrkin, Acta Physicochimica URSS, I, 855 (1935). [4] M. Leontowitsch, ZS. f. Phys., **5**, 58 (1928). [5] G. Krutkow, Bull. Acad. Sci. URSS, 1424 (1933). [6] J. K. Syrkin u. Gladyschew, Acta Physicochimica URSS, II, 291 (1935). [7] Kneser, Ann. d. Physik, 11, 761, 777 (1931). [8] S. I. Wawilow, ZS. f. Phys., **50**, 52 (1928).

* These calculations will appear elsewhere.

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1936. Volume III (XII), № 2 (97)

BIOCHEMISTRY

COLLOIDO-CHEMICAL CHARACTERISTICS OF THE SUGAR BEET, AS DEPENDENT ON ITS CONDITIONS OF GROWTH

By T. T. DEMIDENKO and V. P. POPOV

(Communicated by A. A. Richter, Member of the Academy, 25. V. 1936)

The sugar beet is a complicated colloidal system composed of organic compounds and mineral elements, and a quite valuable agricultural product in which, along with such valuable compound as sugar, there are not a few others some of which are admixtures harmful to beet sugar productions, such as, for example, the hydrophile colloids. The amount of these in the beet depends, not only on the conditions of the plant's mineral nutrition, but likewise on the variety of beet.

The method of quantitative determination of the hydrophile colloids proposed by Prof. Dumanski makes possible a colloido-chemical appraisal of the field technique and fertilizers for the sugar beet, and at the same time solves the problem of the quality of sugar beet sent to the factory. High yields together with high sugar content necessarily imply a beet of the very highest quality, that is to say, a beet containing the smallest possible quantity of harmful admixtures, i. e. colloids hindering sugar manufacture and resulting finally in losses of sugar.

In this work, which was conducted in 1935 in the Voronezh Plant Industry Experiment Station, our purpose was to ascertain the colloido-chemical changes in the sugar beet during the period of its growth and their dependence on field technique as well as on meteorological factors.

The beginning of intensified root formation and storing up of sugar, when the roots weighed not less than 100 grams, was taken as the starting point of our investigation. In order to calculate the influence of precipitation, we timed our collecting of test material to certain definite periods, namely: 1) after rains and 2) during periods of dry, sunny weather.

The results are shown in the table.

Conclusions

On the basis of our study of the dinamics of colloids during the sugar beet's growth, we arrive at the following conclusions:

1. The quantity of colloids in beets is not a constant, but a function of the conditions of growth and, furthermore, a very dynamic one.

Nos	Regime	Col		
		Grams per 100 cm² of diffused juice		
		15/VIII	27/VIII	30/IX
1	Barley	0.3040	1.528	1.400
2	Poppy	—	—	1.238
3	Coriander	—	—	1.139
4	Vetches and Oats I	—	—	1.384
5	Vetches and Oats II	0.3740	1.675	1.336
6	Peas	0.3670	1.608	1.352
7	Sunflower	—	—	1.032
8	Potatoes	—	—	1.362
9	Soy	0.2940	0.934	1.128
10	Maize	0.1830	1.014	1.300

B. Dates of Sowing, Nutrition

Nos	Regime	Col				
		Grams per 100 cm² of diffused juice				
		6/VIII	15/VIII	2/IX	20/IX	7/X
11	Winter plant's	0.534	0.597	0.906	—	1.448
12	Ordinary, 44.5×20 cm = =890 cm²	1.160	1.826	0.960	—	1.228
13	36×36=1296 cm²	1.260	—	0.566	—	1.046
14	44.5×20=890 cm²	1.540	—	0.812	—	1.256
15	Decomposed Manure 20 tons/hectare	1.170	0.851	0.622	0.812	1.259
16	Eresh Manure 20 tons/hectare	1.410	0.849	1.732	0.912	1.240
17	NPK* in rows	1.550	0.867	0.572	0.802	1.246
18	NPK** in rows	1.404	0.697	0.716	0.804	0.814

* The phosphate being in the form of superphosphates.
** The potassium being in the form of sylvinite.

A. Forecrops

loids			Percentage of sugar in the diffused juice			Sugar content at harvest
In % ratios to dry weight						
15/VIII	27/VIII	30/IX	15/VIII	27/VIII	30/IX	30/IX
2.355	11.672	8.786	10.3	8.65	10.95	16.71
—	—	7.854	—	—	11.6	17.91
—	—	7.625	—	—	11.6	17.57
—	—	8.706	—	—	11.6	17.67
2.813	14.129	8.307	9.5	9.3	10.3	17.62
2.656	12.351	8.770	9.65	9.0	11.6	17.46
—	—	6.525	—	—	11.6	17.26
—	—	8.790	—	—	9.65	17.37
1.858	5.869	7.559	10.3	9.0	10.95	17.91
1.059	8.159	8.178	11.7	8.3	11.6	17.87

Areas, Fertilizers Used

loids					Percentage of sugar in the diffused juice					Sugar content at harvest
In % ratios to dry weight of plant										
6/VIII	15/VIII	2/IX	20/IX	7/X	6/VIII	15/VIII	2/IX	20/IX	7/X	7/X
4.846	4.905	7.2789	—	8.9318	7.2	9.4	8.45	—	11.6	17.12
9.510	5.238	6.9883	—	7.3418	8.6	11.2	9.65	—	9.0	17.77
10.761	—	4.1305	—	6.5374	7.65	—	10.0	—	9.3	17.07
12.464	—	5.9222	—	7.6742	8.7		9.9	—	10.95	17.50
9.969	5.8397	4.5382	4.0881	7.5346	8.4	10.95	9.65	12.2	10.85	18.55
12.776	5.910	5.4942	5.7329	7.8345	8.3	10.75	9.8	12.2	10.70	18.24
13.746	5.6968	3.7606	5.0265	7.6129	8.45	10.95	10.1	12.2	10.95	18.32
12.750	4.7685	4.6374	5.1423	4.7476	8.35	10.75	10.3	11.6	10.65	17.65

The quantity of colloids increases in rainy wheather and markedly decreases in dry periods.

2. The quanitity of colloids increases as the beet ripens.

3. The quantity of colloids at the time of harvesting is the resultant of two processes: ageing (ripening) of the beet, on the one hand, and the action of meteorological factors on the beet, on the other hand.

In this connection it may be added that, during rainy weather, both these factors act in the same direction, that is, cooperate toward increasing the amount of colloids in the beet. In dry fall, these factors act in opposite directions: dry weather leads to a decrease in the amount of colloids, while ripening leads to an increase. The result, that is, the amount of colloids in the beet, at this time, represents the excess of one factor over the other in their interaction on the plant.

Potassium fertilizers (sylvinite), despite a special technique of their distribution, not only do not increase the amount of colloids in the beet, but even lower the content of the hydrophile colloids present, the effect from these fertilizers being felt in the second half of the plant's vegetation, at the time of gathering the crop.

5. The legumes, as forecrops, proved excellent conditions for the development of beets, but, at the same time, give them a high content of hydrophile colloids.

6. The content of sugar in the diffused juice is in reverse proportion to the content of colloids in the beet root: in dry weather the percentage of sugar increases, in rainy weather it decreases.

7. Large beets have the highest colloid content; beets of medium size, the lowest.

On the development of scapes the quantity of colloids in the beet root decreases and reaches its minimum in old plants.

8. Decomposed manure gives a better result than fresh one, not only in the development of the beet root and in the accumulation of a greater amount of dry substance, but also in decreasing the amount of colloids.

Setting the plants more thickly (890 cm^2) gives a beet with a higher percentage of dry substance and with greater sugar content, but also with a higher colloid content.

9. Beets give the highest sugar content when manure together with a mineral fertilizer are used. The legumes result in an increase of both sugar content and the amount of colloids.

Voronezh Plant Industry
Experiment Station.

Received
25. V. 1936.

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1936. Volume III (XII), № 2 (97)

PLANT PHYSIOLOGY

ON SOME PECULIARITIES IN THE DEVELOPMENT OF RESISTANT SUNFLOWER FORMS WHEN ATTACKED BY *OROBANCHE CUMANA* WALLR., RACE B.

By L. N. BEREZNEGOVSKAJA

(Communicated by A. A. Richter, Member of the Academy, 26. IV. 1936)

The physiological peculiarities of the resistant forms of the sunflower, *i. e.* of those capable of giving good yields even if attacked by *Orobanche cumana*, Race B,[1] have been but inadequately studied.

A knowledge, however, of the distinctive physiological features of both the resistant and the non-resistant forms of the sunflower might give valuable indications as to the methods of ensuring a more rapid and more rational selectioning of the more resistant forms.

The object of the present work is to compare the amount of transpiration, the general growth and the chemism of the various forms of the sunflower both when sound and attacked by the parasite.

PROCEDURE

The plants used in the experiment were resistant forms of Rostov and Voronezh selection, while two «Fuksinka» numbers represented the non-resistant sunflower.

To determine the amount of transpiration, the experimental plants were grown in vegetation vessels containing 10 kg of soil each. To avoid avaporation, the surface of the soil was covered with paraffined gauze. The amount of moisture lost by the plant was determined daily throughout the vegetation period.

In order to compare the development of the root system in a sound and in attacked plant, the plants used in one series of experiments were grown in lysimeters of 1 m^3 each, while those used in another set of experiments were grown in vegetation vessels.

The material subjected to chemical analysis was supplied by the plants grown in lysimeters.

THE RESULTS OF THE EXPERIMENTS

Changes in the Amount of Transpiration

The amount of transpiration of the non-resistant sunflower forms is greatly diminished when the plant is attacked by the parasite. Its relative fall is the more marked the less resistant the form. As to highly resistant forms, however, their amount of transpiration, far from being reduced, is increased if they are attacked by *Orobanche cumana.*

As to the total loss of moisture by the affected plants throughout the summer, the statistics show that it is in direct proportion to the resistance of the sunflower to the parasite. This is illustrated by Table 1.

Table 1

Total Loss of Moisture and the Amount of Transpiration by Various Sunflower Forms both when Sound and when Attacked by *Orobanche Cumana*

Sunflower forms	Attitude to *Orobanche cumana* race B	Condition of plant	Loss of moisture during vegetation period	Accumulation of dry matter	Amount of transpiration	Difference in amount of moisture lost by sound and by affected plants	Ditto in per centage of loss of moisture by sound plants
«Kirov» Zelenka	Highly resistant	Sound	41 347.5	157.73	3.80	4 794.2	11.3
»	»	Attacked	36 553.3	154.84	4.24		
Fuksinka No 62	Resistant	Sound	38 285.7	137.19	3.59	8 938.0	23.3
»	»	Attacked	29 347.7	85.11	2.90		
Fuksinka No 3	Non-resistant	Sound	39 100.3	153.23	3.92	13.152.0	33.7
»	»	Attacked	25 948.3	73.48	2.83		

The Development of Various Forms of the Sunflower when Attacked by the Parasite.

The increase in the amount of transpiration observable in the resistant forms when attacked by *Orobanche cumana* frequently results in an increase of the total dry matter of the affected plant as compared with the sound control plant. In the first place, the growth of the roots is greatly stimulated.

The figures appearing in Table 2 plainly show the difference in the development of the roots of various forms of the sunflower when attacked by *Orobanche cumana.*

The amplified root system results in a more vigorous development of both the vegetative and the reproductive organs of the plant.

As a result, we have in some instances observed an increased yielding capacity of the resistant sunflower when attacked by *Orobanche cumana,* race B.

Table 2

Change in the Weight of the Roots of Various Forms of the Sunflower when Attacked by *Orobanche Cumana* Experiment carried out in Lysimeters

Name of Sunflower	Attitude to *Orobanche Cumana* race B	Dry weight of roots in grams		Change in weight	
		Sound	Attacked	Absolute figures	Percentage
No 8 885, from Zhdanovka village	Resistant	15.0	17.3	+ 2.3	+ 15.3
«Kirov» Zelenka	»	49.0	68.0	+ 19.0	+ 38.8
Weydell experimental field selektion	»	17.0	18.0	+ 1.0	+ 5.9
Fuksinka No 10	Non-resistant	22.0	7.7	— 14.0	— 65.0
Fuksinka No 3	»	31.0	5.7	— 25.3	— 81.6

Very beneficent has been in this sense the low actual acidity of the soil solution (pH = 7 and 8, cf. Table 3) and the introduction of potassium sulphate into the soil. The latter is accounted for by the ability of the parasite to accumulate in its own system large quantities of potassium (2) by depriving of the latter the system of its host. When a potassium fertilizer is introduced, the plant absorbe an amount of potassium sufficient to satisfy both its own requirements and those of the parasite. The influence of potassium sulphate on the growth of the sunflower when attacked by *Orobanche cumana* is illustrated in Table 4.

Table 3

The Influence of the pH of the Soil Solution on the Development of the Resistant Sunflower («Kirov» Zelenka) and on the Growth of *Orobanche Cumana*, Race B

pH of soil solution	Condition of plant	Dry weight in grams				Weight in grams of seed yielded by one head	Percentage of seed yield
		Overground mass	Root	Head	*Orobanche cumana*		
4	Sound	65.17	7.43	38.4	—	40.85	100
4	Attacked	89.58	7.93	33.39	0.12	18.64	45.6
7	Sound	64.99	4.16	33.39	—	16.29	100
7	Attacked	92.12	9.06	44.92	6.07	27.77	170.4
8	Sound	83.4	4.3	37.3	—	19.71	100
8	Attacked	63.26	5.6	33.55	1.57	32.05	111.8

Remark. Very noticeable is the discrepancy between the volume of the yield and the extent of the development of *Orobanche cumana*. Thus, with pH = 7, the yield of the affected plants increased by 70.4%, while, with pH = 8, the increase was only 11%, although, the growth of *Orobanche cumana* was much greater in the first instance. With pH = 4, the plants were but little affected, but the yield was greatly reduced.

An increased yielding capacity of the resistant sunflower when attacked by *Orobanche cumana* has blln observed in a number of other vegetation

experiments, the results of which it is, however, impossible to give here owing to lack of space. The inference to be drawn therefrom is that, given favourable conditions, the growth of the resistant sunflower is stimulated by the parasite living on it. The action of the latter should be regarded as that of an irritant promoting a vigorous growth of the sunflower.

Table 4

Development of the Resistant Sunflower («Kirov» Zelenka) both when Sound and when Attacked by *Orobanche Cumana*, with Potassium Sulphate Introduced into the Soil

Experimented in vegetation vessels

Dose of K_2SO_4 per 10 kg of soil	Condition of plant	Diameter of head in cm	Dry weight in grams				Weight of seed yielded by one head	Yield of seed in percentage
			Overground mass	Roots	Head	*Orobanche cumana*		
20 g	Sound	8.7	37.05	7.25	33.55	—	21.55	100
20 »	Attacked	12.7	100.9	10.04	49.64	0.09	28.53	132.3
40 »	Sound	9.5	68.31	4.68	28.61	—	16.52	100
40 »	Attacked	11.5	74.53	9.41	39.78	0.68	24.61	148.9
60 »	Sound	10.2	77.92	5.13	37.65	—	19.53	100
60 »	Attacked	12.0	140.91	10.52	43.47	0.58	27.21	139.3

Chemism of Various Sunflower Forms

The chemical analyses of the roots of both the sound and the attacked plants show considerable variations in the amount of nitrogen compounds contained by various forms, *i. e.*, the total amount of nitrogen contained in the roots of sound non-resistant forms is lower than that contained in the roots of sound resistant forms.

If infected, the non-resistant forms accumulate in their roots nitrogen as soluble compounds, the content of protein being lowered.

If the plants attacked by *Orobanche cumana* are of the resistant variety, the behaviour of the nitrogen groups is the reverse of the one just described. The results of the chemical analyses are given in Table 5.

The comparative accumulation or stabilization of protein in the roots of the resistant forms when attacked by *Orobanche cumana* affords an indiret evidence of the formation in the cells of the host of antibodies counteracting the toxic secretions of *Orobanche cumana* (3). Antibodies are known to be proteins (4).

CONCLUSIONS

1. The amount of transpiration of the sunflower, when attacked by *Orobanche cumana*, race B, diminishes the more the less resistant the plant with regard to the parasite. Those varieties of the sunflower, however, as are strongly resistant to that parasite, increase their transpiration when attacked by it.

Table 5

Amount of Various Forms of Nitrogen in the Roots of Sunflower in Sound and Attacked Plants

Name of sunflower	Attitude to attacking parasite	Condition of plant	Total nitrogen	Protein nitrogen	Ratio of protein to total nitrogen
«Kirov» Zelenka	Resistant	Sound	1.32	0.87	0.68
«Kirov» Zelenka	»	Attacked	0.90	0.59	0.65
N 8885, Zhdanovka village	»	Sound	1.01	0.75	0.74
N 8885, Zhdanovka village	»	Attacked	0.99	0.86	0.86
Fuksinka N 10	Non-resistant	Sound	0.80	0.76	0.94
» N 10	»	Attacked	1.26	0.49	0.50

Remark. For «Kirov» Zelenka, the ratio of protein to total nitrogen is taken to be the same whether the plant is a sound or an attacked one.

2. This results in an increased accumulation of dry substance by resistant forms when attacked by the parasite. Most frequently, the growth of the roots is stimulated in this manner, the other organs follow suit, and, not infrequently, the seeds also show a more vigorous development.

3. The increase of the yielding power of the resistant forms of the sunflower is partly due to the introduction of potassium sulphate into the soil.

4. When a plant is attacked by the parasite, the nitrogen content of the roots is differently affected according to the form of the sunflower: the non-resistant forms increase their total nitrogen content mainly as soluble compounds, while the content of protein is diminished; as to the resistant forms, the total amount of nitrogen is diminished, and, as compared with it, the amount of protein nitrogen is either increased or remains unchanged.

Section of Plant Physiology,
Regional Experimental Station.
Voronezh.

Received
26. IV. 1936.

REFERENCES

[1] Л. Жданов, Труды Всесоюзного съезда ген., сел. и сем., т. IV. (1929), [4] Zellner, Monatsh. f. Chemie, 40 (1919). [3] Kostoff, Genetics (1929). [2] Х. Г. Уэллс, Химия иммунитета (1929).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1936. Volume III (XII), № 2 (97)

GENETICS

ON THE DIVERSITY OF SEX EXPRESSION IN PLANTS AS ILLUSTRATED BY THE *CUCURBITACEAE*

By K. I. PANGALO

(Communicated by N. I. Vavilov, Member of the Academy, 15. V. 1936)

All the diversity of sex expression in plants is conditioned by the presence of three types of flowers: male, female, and hermaphrodite. These flower types, encountered separately or in one or another combination, determine the sex types of individual plants. Correns(1) enumerated seven such types, *i. e.*, all that he considered theoretically possible:

Hermaphrodite	plants with	☿	flowers
Gynomonoecious (and gynodioecious)	» »	☿ + ♀	»
Andromonoecious (and androdioecious)	» »	☿ + ♂	»
Trimonoecious (and tridioecious)	» »	☿ + ♀ + ♂	»
Monoecious	» »	♀ + ♂	»
Gynoecious (female or pistillate)	» »	♀	»
Androecious (male or staminate)	» »	♂	»

The presence within the limits of Linnean species of individual plants belonging to one or another of the above-listed types determines the sex categories of the plant world. According to a summary made by the Yampolskys (2), who classified as to sex types 120 000 botanical species described in literature, there are a total of eleven such categories. V. A. Monyushko (3) and M. A. Rozanova (4), however, do not agree with the Yampolskys as to this total, believing that there is considerably greater diversity of sex manifestation in plants. But they, too, have founded their theses on the same three types of flowers and seven sex types of individual plants as did Correns.

Investigations of the Institute of Plant Industry on the *Cucurbitaceae* have revealed, in addition to the three commonly recognized flower types, a fourth type, which, although also quite generally known in the plant world, nevertheless has, for some reason, not been taken into consideration by Correns or anyone else in working out a system of sex diversity. This fourth type is that of a hermaphrodite flower with a semi-inferior, actually superior ovary and a broad, urn-shaped receptacle, touching but not adhering to the walls of the ovary. Flowers with such a semi-inferior ovary are found in the *Cucurbitaceae*, *Rosaceae*, *Saxifragaceae*, and a number of other families.

Among cultivated *Cucurbitaceae* such flowers have been found in the genera *Cucurbita*, *Citrullus*, *Luffa*, and *Cucumis*, especially often in the last-mentioned, notably in the species *Cucumis chinensis* Pang. Within this species there is one rare variety, the «Mongolian cucumber», which has flowers solely of the described type.

The hermaphrodite flowers of the «Mongolian cucumber» are distinguished by short, cylindrical superior ovaries and five separate, single stamens, and also by the fact that they are always grouped in loose cymose inflorescences*. The fertility of these flowers is fully normal. In squashes the described flower type does not constitute a special attribute of any particular species or variety, but occurs infrequently, the entire habit of the flower usually indicating some abnormality. Only rarely do fruits set from such flowers. This holds true not only for squashes, but also for watermelons and gourds (*Luffa*).

Naturalists of the middle of the past century ([5]) already knew of the existence of flowers of the described type in the *Cucurbitaceae;* contemporary investigators ([6]) have likewise written about them; but both the former and the latter considered their occurrence on plants as something accidental, teratological. The investigations of the Institute of Plant Industry, however, indicate that this is not the case.

Investigation of male flowers in *Cucumis* shows that at the bottom of the broad, urn-shaped receptacle there is an undifferentiated tubercle, constituting a rudimentary ovary, which varies in size in different varieties, sometimes attaining the size of a small, normal ovary and even having a style. Such flowers very closely resemble those of the «Mongolian cucumber» described above, and constitute clear and indubitable transitional forms between them and pure male flowers. Similar transitional forms, with inferior ovary, exist between female and hermaphrodite types of flowers in *Cucumis*; but in this case it is the stamens which are rudimentary.

There is no doubt but that these transitional forms are not accidental, that they represent stages or steps in the evolutionary process, whereby at some time in the past the hermaphroditism of the *Cucurbitaceae* evolved into diclinism—monoecism and dioecism. Proceeding from the premise that pure male flowers and pure female flowers with an inferior ovary are the final types toward which flowers in *Cucumis* are evolving, one may designate the phylogenetically earlier hermaphrodite forms with an inferior ovary «gynogenic» and those with a superior ovary «androgenic».

In accordance with the general scheme of development of sex in the higher flowering plants proposed by Darwin—hermaphroditism → polygamy → dioecism—and confirmed for the *Cucurbitaceae* by Correns, this process of evolution may now, using *Cucumis* as an example, be established in greater detail.

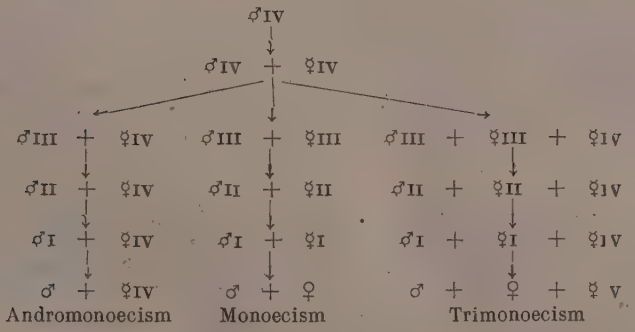
The type most closely approximating the initial hermaphrodite flower in the *Cucurbitaceae* is the androgenic-hermaphrodite type. By the coalescence of the urn-shaped receptacle with the ovary the androgenic-hermaphrodite type might easily have been converted into the gynogenic-hermaphrodite type. Subsequently, both these types, by the degeneration either of the gynoecium or of the androecium, might easily have developed—through a series of gradual transitions, such as indicated in the diagram-

* In other cultivated varieties and species of *Cucumis* the ovary is always inferior. There are three stamens, one single and two double (grown together); the female and hermaphrodite flowers are always solitary, while the male flowers are always borne in clusters.

Diagram of Structural Variations in Androe ia and Gynoecia in Hermaphrodite Flowers and Symbols for t eir Designation

Androecium in female flower (gynogenic hermaphroditism)		Gynoecium in male flower (androgenic hermaphroditism)	
Description	Symbol	Description	Symbol
Undifferentiated tubercles on the petals of the corona—staminody	♀or ♀o	Undifferentiated tubercle at the bottom of the receptacle—pistillody	♂or ♂o
Tubercles elongated and larger in size	♀I	Tubercle larger in size	♂I
Stamen filaments but no anthers.	♀II	Ovary either with a style or only a stigma, often deformed . . .	♂II
Stamens with poorly formed anthers	♀III	Ovary with style and stigma but deformed	♂ II
Normal stamens with fertile pollen	♀IV	Normal, fructifying ovary	♂IV

—three new flower types: pure male, pure female with inferior ovary, and pure female with superior ovary (our investigations did not reveal the last-named in the collections of the Institute of Plant Industry). Combining in different ways, the indicated flower types might form all the categories of sex expression in *Cucumis*. Below is given a diagram outlining the possible course of evolution of the three chief sex categories in this genus:



This diagram of sex evolution in *Cucumis*, an expansion of Correns's diagram, does not include any hypothetical links, since: (a) all the indicated stages in the gradual formation of andromonoecism, monoecism and trimonoecism have been established among the collections of the Institute of Plant Industry in the form of constant varieties; (b) the gyno-androgenic monoecious type (♂IV+♀IV), formed hypothetically from the androgenic hermaphrodite type (♂), also exists—not in the collections, but in the F_2 from Hybrid No 34 described below; (c) the initial androgenic hermaphro-

dite type (♂) exists in the Institute's collections in the form of the «Mongolian cucumber» already described*, which belongs to the botanical species *Cucumis chinensis* Pang.

All that we have said above regarding *Cucumis* is, most probably, applicable to the *Cucurbitaceae* as a whole, since androgenic-hermaphrodite forms are encountered, as we have already mentioned, not only in the genus *Cucumis* but also in the genera *Cucurbita*, *Citrullus*, and *Luffa*. It is true that in these latter genera there has not yet been found such forms as the «Mongolian cucumber», bearing flowers only of the initial androgenic-hermaphrodite type, and that androgenic-hermaphrodite flowers are of rare occurrence on plants of these genera, are not perfectly true to type, and frequently are not fertile. Nevertheless, this does not invalidate our generalization, but only indicates that these genera, as regards the evolution of their flowers, have evolved further from the hermaphrodite ancestors of present-day *Cucurbitaceae* than the genus *Cucumis*.

The occurrence in the *Cucurbitaceae* not of three (♂, ♂, ☿) but of four flower types (♂, ♀, ♂, ☿) makes necessary, as has already been noted, important alterations in the diagram of sex types of plants proposed by Correns, and to include therein not seven but fifteen types, as listed below:

System of Diversity of Sex Types in the *Cucurbitaceae* **:

1) ♂	androecism	11) ♂ + ♂ + ♀	androgenic trimonoecism
2) ♀	gynoecism		
3) ♂	androgenic hermaphroditism	12) ♂ + ☿ + ♀	gynogenic trimonoecism
4) ☿	gynogenic hermaphroditism		
5) ♂ + ♀	monoecism	13) ♂ + ♂ + ☿	gyno-androgenic andro-trimonoecism
6) ♂ + ♀	androgenic gyno-monoecism		
7) ☿ + ♀	gynogenic gyno-monoecism	14) ♂ + ☿ + ♀	gyno-androgenic gyno-trimonoecism
8) ♂ + ♂	androgenic andro-monoecism		
9) ♂ + ☿	gynogenic andro-monoecism	15) ♂ + ♂ + ♀ + ☿	gyno-androgenic tetra-monoecism
10) ♂ + ☿	gyno-androgenic monoecism		

Of these fifteen theoretically possible types in the genus *Cucumis*, constituting the maximum diversity of sex expression, there have as yet been found only six, viz., Nos 3, 5, 9, 12, 13, and 15. The other nine either exist and have not yet been discovered, which is of little probability, taking into consideration that 3 500 specimens of *Cucumis* in the wolrd collections

---

* Speaking about the evolution of flower and sex types in the *Cucurbitaceae*, it is interesting to note that the majority of species and varieties bearing flowers of the initial androgenic-hermaphrodite type originated in the ancient center of origin of cultivated plants, the Japanese-Chinese center.

** Since flowers with semi-inferior ovaries (androgenic hermaphrodites) are found not only in the *Cucurbitaceae* but also in other families, the proposed system of diversity of sex types of plants may have move general significance.

As stated above, it is theoretically possible that in the process of evolution of flowers in the *Cucurbitaceae*, besides the four flower types mentioned, there might be formed a fifth—pure female with superior ovary. If this type should be discovered, the system of sex types in the *Cucurbitaceae* would have to be considerably extended, for it would include 31 instead of 15 types.

of the Institute of Plant Industry have been studied; or for some reason were never formerd in nature, which also seems scarcely plausible;or, lastly, and this appears most probable, were formed but proved, possibly, to be only stightly viable and so died out. Hence, it seemed of great interest to attempt the artificial synthesis of sex forms not found in nature but theoretically possible, and in this way to verify the system of fifteen sex types of plants we have here advanced.

All-Union Institute of Plant Industry
Detskoje Selo. Leningrad

Received
5. V. 1936

REFERENCES

[1] C. Correns, Bestimmung, Vererbung und Verteilung des Geschlechtes bei höheren Pflanzen. Handb. Vererbungswiss., II (1928). [2] C. and. R. Yampolsky, Bibliotheca Genetica, III, 1—62 (1922). [3] В. А. Монюшко, Труды по прикл. бот., ген. и сел., II, вып. 2 (1936) [4] М. А. Розанова, Проблема пола у высших растений, теоретические основы селекции, т. I (1935). [5] C. Naudin, Ann. Sic. Nat., ser. V, vol. IV (1855). [6] G. Durham, ZS. Ind. Abst. Vererb., 37, 358—361 (1925); Lyashchenko, C. R. Acad. Sci. URSS, No 7 (1934); A. Pirovano, La mutazione elettrica della specie botaniche e la disciplina dell'eredita nell'ibridazione (1922); R. Savelli. Bull. Soc. Bot. Ital., 71—76 (1926); R. Savelli, Nuovo, Giorn. Bot. Ital., vol. 33 (1926);—T. W. Whitaker, Amer. Jour. Bot., 18, No 5, 359—366 (1931).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1936. Volume III (XII), № 2 (97)

GENETICS

ON GENES DETERMINING DIFFERENT SEX TYPES IN PLANTS AS ILLUSTRATED BY THE *CUCURBITACEAE*

By K. I. PANGALO

(Communicated by N. I. Vavilov, Member of the Academy, 15. V. 1936)

The present article is a continuation of the writer's previous one on the diversity of sex manifestation in plants as illustrated by the *Cucurbitaceae*. The occurrence in *Cucumis* not only of male and female flowers, but also of two types of hermaphrodite flowers—androgenic and gynogenic makes the existence of fifteen sex types of plants (instead of seven, as given by Correns) theoretically possible. An examination of over 3 500 specimens *Cucumis* in the world collections of the Institute of Plant Industry revealed only six different sex types. It seemed of great interest, therefore, to attempt to verify our hypothesis as to fifteen possible sex types in the *Cucurbitaceae* by hybridization experiments designed to create these sex types.

Among a number of hybrids produced by the Institute of Plant Industry with this aim in view, one—№ 34—served the purpose intended. This hybrid was obtained from a cross between a perfectly diclinous monoecious plant, *Cucumis flexuosis* L. (Tarra) and a typical, androecious plant, *Cucumis chinensis* Pang. (Mongolian cucumber). These two species cross very readily, and in the F_1 perfect diclinism is dominant. The F_2 segregates into extremely diverse sex types, as shown in the following table:

F_2 Segregation of Hybrid No 34

F_2 sex types	No of plants
♂	—
♂ + ♂	—
♂	2
♂ + ♂ + ♀	11
♂ + ♂ + ♀	73
♂ + ☿	7
♂ + ♂ + ♀ + ☿	35
♂ + ♀	130
♂ + ☿	6
♂ + ♀	22
♂ + ♀ + ☿	21
♂ + ♀ + ☿	18
☿	3
♀ + ☿	3
♀	7
Total	338

Here we have all the sex types theoretically possible according to our hypothesis set forth above with the exception of two, ♂ and ♂+♂. But their absence in this case does not exclude the possibility of their existence, and may easily be explained by the small number of F_2 plants, evidently insufficient for the full manifestation of all categories of segregation. This is confirmed by the circumstance that these two sex types, ♂ and ♂+♂ did appear in the progeny of another hybrid, from a cross between the same Mongolian cucumber and the Koy-bash melon.

Of greatest interest of all the F_2 plants from Hybrid No 34 are the pure female forms, since they testify to the synthesis of dioecism (taking into account the pure male plants in the F_2 from the cross Mongolian cucumber × ×Koy-bash melon). It is true, this dioecism has not yet acquired due stability, for the male plants at the very end of the vegetative period bear one or two female flowers, while the progeny from fruits of female plants fertilized by male plants is extremely varied instead of segregating into male and female individuals only. This, however, merely indicates that dioecism is a complex character, which phylogenetically was developed, in all probability, very gradually, by natural selection and an accumulation of corresponding genes.

Since the F_3 of this hybrid has not yet been grown, it is as yet impossible to complete our genetic analysis. Provisionally, however, basing our statement only on data from a small F_2 showing close approximation between actual and expected results, it is possible to say even now that there are a large number of genes determining the above-mentioned sex types*.

First of all, we have conditionally established the existence of two genes for flower type: *F*—female (with inferior ovary) and *M*—male, *M* being epistatic to *F*. The character of segregation for flower type indicates the probable existence of three inhibiting genes: *C*—completely suppressing the gene *M* and thereby making it possible for the gene *F* to manifest itself; and the multiple genes *B* and *D*, epistatic to *C* and partially suppressing the gene *M*, as a result of which plants of the type *MFCAE*, *MFCaB*, and *MFCAB* bear both male and female flowers. In addition, one must assume the existence of three multiple genes—*E*, *H*, and *I*—producing a pleiotropic effect. First, by their combined action they determine dioecism, so that the absence of even one of them results in plants with hermaphrodite flowers. Secondly, the gene *E*, when dominant, produces plants with hermaphrodite flowers of gynogenic origin. The same gene, in combination with the dominant gene *H* or *I*, produces plants with hermaphrodite flowers androgenic in type; while, when it is recessive, whether in combination with *H* or *I* or without these genes; it determines plants with hermaphrodite flowers both androgenic and gynogenic in type. Lastly, one must assume the existence of polymeric genes for the androecium and the gynoecium—*A*, A_1, A_2 and *G*, G_1, G_2—determining quantitative differences in expression of the androecium and gynoecium in bisexual flowers. Hence, all the existing and possible sex types of plants in *Cucumis* are probably determined by not less than 10 genes: *M*, *F*, *C*, *B*, *D*, *E*, *H*, *I*, *A*, *G*. It is very probable tha also in other genera of the *Cucurbitaceae* the matter is equally complex.

Correns (1928) considered it possible to explain all the sex types in the *Cucurbitaceae* by the presence of three genes: *A*—androecium, *G*—gynoecium,

---

* The description of the methods employed in and numerical data obtained from our genetic analysis are not given here, but will be published in the «Bulletin of Applide Botany, Genetics and Plant Breeding».

and Z, a gene determining the place of development of androeci ım and gynoecium. Now, however, it is apparent that such a hypothesis is considerably too simple. Later on, of course, after a study has been made of the F_3 and F_4 of hybrid No 34 and a number of others, it will probably be necessary to revise the list of genes here provisionally proposed, but it seems unlikely that as a result of such revision the list will be shortened or simplified.

All-Union Institute
of Plant Industry

Received
15. V. 1936.

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1936. Volume III (XII), № 2 (97)

GEOLOGY

THE DISTRIBUTION OF LOWER SARMATIAN DEPOSITS ON THE NORTH-WESTERN OUTSKIRTS OF THE DONETS BASIN

By K. S. USENKO

(Communicated by A. A. Borissiak, Member of the Academy, 4. V. 1936)

During the summer seasons of the years 1934 and 1935, on the instruction of the Institute of Geology of the Kharkof State University, I investigated the Slavyansk region lying within the valley of the Sukhoy Torets. Of all the data obtained, the most interesting is the occurrence of neogene sands with Lower Sarmatian fauna 12 km south-south-west of Slavyansk.

5 km from the mouth of the Mayachka, a left tributary of the Kazyonny Torets, in the upper part of the Rossokhovataya gulch near Schabelkofka village (Mayachka), is situated a quarry with the following outcrops:

1. Gray humus sandy loam 0.30
2. Brownish-gray sandy loess-like carbonaceous loam 1.20
3. Brownish-red clayey sand containing in its lowest parts gravel grains and individual pebbles 2.00
4. Fine gravel 0.15
5. Variegated brownish-red clayey sand with gray spots passing into the underlying horizon 2.00
6. Whitish-yellow cross-bedded sand of different granulation containing in places small individual concretions of quartzose sandstone, on the periphery of this sand fossil shells *Ervilia podolica* occur; the same shells, in a good state of preservation, occur in one of the sand seams stretching along the wall of the quarry from the base of the outcrop to the upper boundary of the sands at an angle of 30°; the dip of the seam with *Ervilia podolica* is W.S.W 190°; the visible thickness. 8.00

In our opinion, such a stratification may be explained by the coastal conditions of the deposition of the sediments, and not by a dislocation subsequent to the formation of the strata.

In the sands of this outcrop I collected about 27 fossil shells, 18 of them being in a remarkable state of preservation.

Besides the shells of *Ervilia podolica*, there were found in the sands of the Rossokhovatski quarry fragments of a sea urchin, but in such a bad state of preservation, that it was impossible to identify them. In the

course of a microscopic analysis of the sands a great many foraminiferous shells of the genus *Nodosaria* were discovered. All these palaeontological remains are in a state of fossilization and do not dissolve in a weak hydrochloric acid.

Up to the present time no statements concerning the extension of the Lower Sarmatian Sea on the north-western outskirts of the Donets Basin have been made. The nearest deposits containing Sarmatian fauna and represented by sandy facies have been described by A. A. Gapeyev (2).

Northwestwards from Mezhevaya station, along the Lozovaya gulch (a left tributary of the Samara river), in a yellowish-brown cloddy sandstone, among white sands, nuclei of fossils were found, among which *Cardium* sp., *Modiola* sp., *Mactra podolica*, *Tapes* sp., *Ervilia* sp. have been identified. According to A. V. Gurov (1), in the same gulch, 8 km westwards from the outcrop indicated by Gapeyev, in loose sansdtone and sands, Edelstein found distinct impressions of *Cardium protractum* and *Trochus podolicus*.

The above-mentioned outcrops of rocks with Sarmatian fauna are situated 100 km south-west of that of the Mayachka (the Rossokhovataya gulch), while on Gapeyev's geological map a Sarmatian horizon is marked at a distance of 50 km south-west of the outcrop of the Sarmatian in the Mayachka valley, no outcrops or fauna that might characterize the Sarmatian horizon being described in the text.

On the basis of all these data it may be concluded that the Lower Sarmatian sands extend into the north-western outskirts of the Donets Basin.

Institute of Geology.
Kharkov State University.

Received
4. V. 1936.

REFERENCES

[1] А. В. Гуров, Гидрогеологические исследования Павлоградского и Бахмутского уездов Екатеринославской губ. (1893). [2] А. А. Гапеев, Матер. по общ. и прикладн. геологии, вып. 123, 49 (1927).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1936. Volume III (XII), № 2 (97)

ZOOLOGIE

ÜBER DAS ÜBERLEBEN DES SPERMAS VON ACIPENSERARTEN UNTER VERSCHIEDENEN ÄUSSEREN VERHÄLTNISSEN

Von A. I. SCHMIDTOW

(Vorgelegt von S. A. Zernov, Mitglied der Akademie, d. 24. V. 1936)

Während der Arbeit mit künstlicher Befruchtung der Acipenserarten kommt es öfters vor, dass unter den gefangenen Fischen geschlechtsreife Stör- und Sterletmännchen fehlen, so dass ein Teil des gewonnenen Rogens unbefruchtet bleibt. Diese Erscheinung lässt sich in Tatarien besonders oft bei dem Stör (*Acipenser güldenstädti*) beobachten, dessen Rogen entweder unbefruchtet bleibt oder mit Sterletmilch befruchtet wird. Es ist klar, dass solche Hybriden sowohl von wirtschaftlichem, als auch von biologischem Standpunkt weniger vorteilhaft sind. Dieser Umstand veranlasste uns eine Reihe von Versuchen anzustellen, um die Verhältnisse, unter welchen eine Aufbewahrung lebender Stör- und Sterletmilch als Vorrat möglich ist, aufzuklären. Während der Jahre 1932—34 wurden Beobachtungen über das Überleben «trockener» Milch, und in Alkohol- und Chloroformlösungen verschiedener Konzentration aufbewahrter Milch angestellt. Ausserdem wurden Beobachtungen über das Überleben der Stör- und Sterletspermien in «natürlichen Verhältnissen», d. h. in gewöhnlichem Wasser, und während des Transports lebender Milch von einer Fischzüchterei zu einer anderen zwecks künstlicher Befruchtung von Stör- und Sterletrogen angestellt. Die Milch wurde nur von völlig geschlechtsreifen Männchen genommen und in sterilisierte Reagenzgläser unter Beachtung aller Sterilitätsregeln gesammelt. Die Genitalöffnungen der Männchen wurden mit sterilisierter hygroskopischer Watte abgerieben und die erste Portion der frei abfliessenden Milch in der Regel nicht gesammelt. Die Reagenzgläser wurden mit steriler Watte oder mit den im Alkohol desinfizierten Korkpropfen verschlossen. Im Protokoll wurden Grösse des Männchens, Zeit der Probeentnahme, Aktivität der Spermien während der Probeentnahme, Zeitpunkt des Absterbens der ersten und der letzten Spermatozoide verzeichnet. Die Mehrzahl (75—85%) der Spermien der aufbewahrten «trockenen Milch» behielten ihre Aktivität 12 bis 19 Tage, einzelne Exemplare bis 21 Tage. Die relativ geringe Lebensfähigkeit von 3—5 Tagen in 2 Spermien-Proben lässt sich hauptsächlich durch Nichtbefolgung der Sterilitätsregeln erklären, wie auch offenbar durch die sharfen Temperaturschwankungen von 2 bis 20° C beim Transport der Milche ohne Thermos

aus dem Keller ins Zimmer. Die unbedeutende Lebensfähigkeit der Spermien des Männchens No 4 lässt sich durch die niedrige Qualität der Milch selbst erklären, beim Männchen No 18 erwies sich die Milch pathologisch verändert—bewegliche Spermien waren schon am Anfang nur in minimaler Anzahl vorhanden.

Eine derartige Erscheinung ist hauptsächlich gegen Ende der Laichperiode zu beobachten. Die Beobachtungen an flüssiger fast durchsichtiger Milch zeigten, dass in letzterer sehr wenig Spermatozoide vorhanden sind, und dass diese beim Aufbewahren am 2. oder 3. Tage eingehen. Folglich ist deren Aufbewahrung als Vorrat nicht möglich. Von mehreren Männchen in ein Reagenzglas gesammelte Milch geht nach unseren Beobachtungen gleichfalls im Laufe der drei ersten Tage zugrunde. Die besonders grosse Lebensfähigkeit einzelner Spermien bis zu 21 Tagen muss durch die hohe Qualität der Milch selbst und sorgfältige Anstellung der Versuchsanordnung in betreff der Sterilität und Temperaturkonstanz erklärt werden. Die Zustellung der Milche von den Männchen No 17—20 vom Fangort nach Kasan dauerte 38 Stunden und erfolgte in einem Thermos mit Eis, bei der Temperatur 2—4°C. Nach ihrer Zustellung nach Kasan wurde die «trocken»-aufbewahrte Milch täglich einer Durchsicht unterzogen, bis die letzten Spermatozoiden zugrunde gegangen waren, also während 21 Tagen. Am 15—17 Tage waren in der Milch einzelne unbewegliche Spermatozoide und kleine Organismen von rundlicher Form, offenbar Bakterien, nachweisbar. Ein analoges Bild war auch in anderen Versuchen zu beobachten. Folglich schienen die Bakterien die Ursache des Zugrundegehens der aufbewahrten Spermatozoide zu sein da dieses parallel mit der Vermehrung der Bakterien fortschreitet. Die angestellten Versuche haben gezeigt, dass das aufbewahrte Sperma für künstliche Befruchtung verwertbar ist. Wir haben unter Beteiligung des Präparators der Universität Kasan, J. P. Koksin Sterletrogen mit 12 Tage aufbewahrter «trockener» Milch» befruchtet und gute Resultate erzielt. Bei Verwendung sowohl frischer, als auch «trocken» aufbewahrter Milch muss diese vorher mikroskopisch untersucht werden, da frisch gewonnene Milch manchmal abgestorben oder pathologisch verändert sein kann, was wir mehrfach während unserer Arbeit beobachtet haben. Bei niedriger Temperatur ist gewönlich keine Bewegung der Spermien in «trokken» aufbewahrter Milch zu beobachten; wird aber ein Tropfen Wasser unter das Deckglas des Präparats eingeführt, so beginnen sehr aktive Bewegungen, die 40—45 Minuten andauern, d. h. bis zum Eintrocknen des Präparats, da das Hinzufügen eines neuen Tropfens wieder aktive Bewegungen der Spermien auslöst. Die Farbe und der Geruch der Milche bleiben während des Versuchs bis zum Zugrundgehen der Spermien normal.

Ausser den eben beschriebenen Versuchen wurden noch Beobachtungen über das Überleben der Spermien in Alkohol-und Chloroformlösungen und unter «natürlichen Verhältnissen» angestellt. Aus diesen Versuchen ist zu ersehen, dass im Thermos aufbewahrte Spermien in Reagenzgläsern mit ½%-iger Lösung rektifizierten Alkohols 3 bis 6 Stunden lebensfähig sind, in 1%-iger Alkohollösung 3—4 Tage, in 2%-iger bis 17—20 Tage.

In den Versuchen mit Aufbewahrung der Spermien in Alkohollösungen war zu sehen, dass nach einiger Zeit die aktiven Bewegungen der Spermien völlig aufhörten und diese in den Zustang der Anabiose verfielen, wie in der trockenen Milch; wurde aber ein Tropfen Wasser zur untersuchten Probe hinzugefügt, traten wieder sehr aktive Bewegungen ein, die 40—45 Minuten, also bis zum Eintrocknen des Präparats andauerten. Ein solcher Zustand der Milch dauerte in den Versuchen 15—17 Tage; darauf traten Bakterien auf und nach 2—3 Tagen waren schon keine lebenden Spermien mehr nachweisbar.

In 3%-iger Alkohollösung gehen unter sonst gleichen Bedingungen die Spermatozoiden in 3—4 Stunden zugrunde. Zweifellos ist diese Kozentration tödlich.

In den Versuchen mit Aufbewahrung der Spermien in Chloroformlösungen von derselben Konzentration gehen die Spermien unter anormal verstärkten Bewegungen in 10—60 Minuten zugrunde. Besonders schnell streben sie bei hohen Konzentrationen (ca. 3%) ab.

Ausserdem haben wir Versuche zur Feststellung der Lebensfähigkeit frischer Milch und 12 Tage in «trockenem» Zustand oder 2%-iger Alkohollösung aufbewahrter Milch in «natürlichen Verhältnissen» angestellt, d. h. in gewöhnlichem Kamawasser bei 12—13° C. Einige Tropfen der Milch wurden in Reagenzgläser mit 4—5 cm^3 Kamawasser gebracht. Die mikroskopische Untersuchung ergab, dass beim Sterlet fast 100% der Spermien im Wasser ihre aktiven Bewegungen während 3—4 Stunden durchschnittlich beibehalten. Darauf wird die Beweglichkeit geringer und am Anfang der 5 Stunde sind nur 40—50% beweglich. Gegen Ende der 5. Stunde sind nur einzelne Individuen beweglich, die bis 5—6 Stunden leben. Die Bewegungen der Spermien werden gegen Ende unregelmässig: nach einzelnen Stössen treten Ruheperioden ein. In den Versuchen mit der als Vorrat aufbewahrten Milch konnte festgestellt werden, dass etwa 90—95% der Spermien im Wasser während 1—2 Stunden leben. Nach 2—2½ Stunden gehen etwa 40—50% der Spermien zugrunde, und gegen Ende der 5. Stunde sind nur einzelne lebende Exemplare anzutreffen.

Bei gleicher Behandlung des Sperma des Störs (*Acipenser güldenstädti*) gelang es uns, dieses in lebensfähigem Zustand 5 bis 8 Tage zu erhalten. Über die Möglichkeit eines längeren Vorrätighaltens der Störmilch lässt sich infolge der geringen Zahl der Versuche noch nichts sagen. Unter «natürlichen Verhältnissen», d. h. im Wasser, beträgt die Lebensdauer einzelner Störspermien 4½ Stunden, der grösste Teil jedoch geht in 2—3 Stunden zugrunde. Die beschriebenen Versuche zeigen, dass die Spermatozoiden der Acipenserarten (*Acipenser ruthenus* und *Acipenser güldenstädti*) gegenüber den Spermien anderer Fischarten die grösste Stabilität aufweisen. Aus Obenerörtertem lassen sich folgende Schlüsse ziehen. Unter natürlichen Verhältnissen kann manchmal beim Stör und Sterlet Milch mit Spermien von geringer Lebensfähigkeit angetroffen werden, deshalb müssen sie vor ihrer Verwendung für die künstliche Befruchtung unter dem Mikroskop untersucht werden. Milch von hoher Qualität ist bei den Acipenserarten sehr stabil und ihre Spermien leben in natürlichen Verhältnissen 2—4 Stunden, einzelne Spermatozoiden bis 5—6 Stunden.

«Trockene Milch», frei von jeglichen Beimengungen lässt sich bei völlig steriler Gewinnung und bei $t° = 1—4°$ C im Zustand der Anabiose bis 17—18 Tage, einzelne Spermien sogar bis 21 Tage vorrätig halten. Die vorrätig gehaltene «trockene Milch» des Störs und des Sterlets kann für die künstliche Befruchtung verwendet werden, wobei vollkommen befriedigende Resultate erzielt werden.

Das Überleben der Spermien in 0.5 bis 3%-igen Chloroformlösungen schwankt von 10 bis 60 Minuten. Bei höheren Konzentrationen gehen sie rascher zugrunde

In 0.5 bis 3%-igen Lösungen rektifizierten Alkohols lässt sich eine Verlängerung der Lebensdauer der Spermien mit dem Ansteigen der Konzentration bis 2% beobachten; bei 2%-iger Lösung erreicht sie ihr Maximum, während eine weitere Erhöhung der Konzentration das Sperma schon abtötet. Das Wasser übt auf aufbewahrte Milch eine belebende Wirkung aus.

Zoologisches Kabinett
der Universität Kasan.

Eingegangen
d. 24 V. 1936.